



# Pacific Island Network Vital Signs Monitoring Plan

## Appendix A: Puuhonua o Honaunau National Historical Park Resource Overview

Page Else (HPI-CESU)

### Pacific Island Network (PACN)

#### **Territory of Guam**

War in the Pacific National Historical Park (WAPA)

#### **Commonwealth of the Northern Mariana Islands**

American Memorial Park, Saipan (AMME)

#### **Territory of American Samoa**

National Park of American Samoa (NPSA)

#### **State of Hawaii**

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

*Suggested citation:*

Else, P. 2006. Appendix A: Puuhonua o Honaunau National Historical Park resource overview. *In:* HaySmith, L., F. L. Klasner, S. H. Stephens, and G. H. Dicus. Pacific Island Network vital signs monitoring plan. Natural Resource Report NPS/PACN/NRR—2006/003 National Park Service, Fort Collins, Colorado.

*Last revision:* April 2005

*Organization contact information:*

National Park Service (NPS), Inventory and Monitoring Program, Pacific Island Network, PO Box 52, Hawaii National Park, HI 96718, phone: 808-985-6180, fax: 808-985-6111,

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU), University of Hawaii at Manoa, 3190 Maile Way, St. John Hall #408, Honolulu, HI 96822-2279

Pacific Island Ecosystem Research Center (PIERC), Kilauea Field Station, Building 344, P.O. Box 44, Hawaii National Park, HI 96718

*Acknowledgements:*

This appendix was prepared with assistance from the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit (HPI-CESU), Task Agreement Number: J8080050039.

## EXECUTIVE SUMMARY & INTRODUCTION

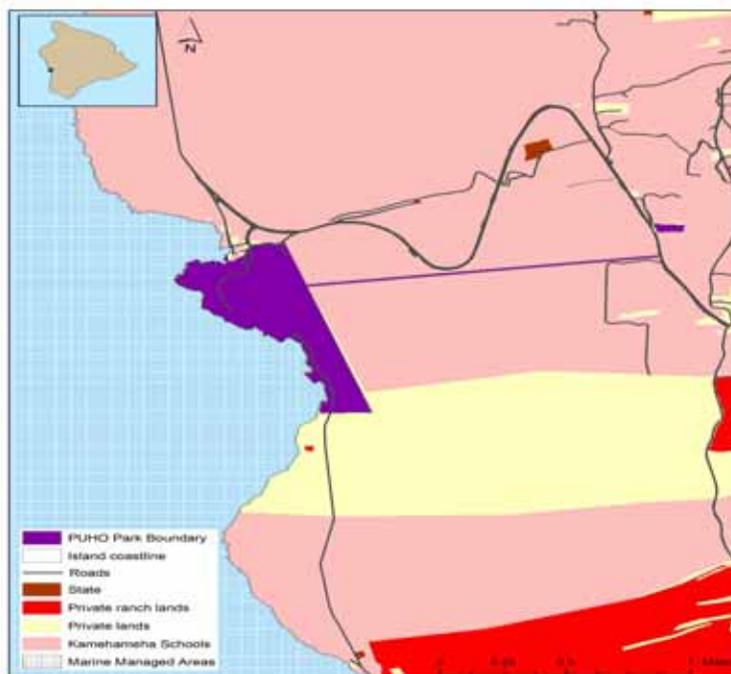
### Enabling Legislation

The City of Refuge National Historical Park (NPH) was authorized by Congress on July 26, 1955 (Public law 95-625). Lands were transferred to the NPS in 1961. The park was established for the “benefit and inspiration of the people” due to its historical and cultural significance. The park area was the seat of power for the Kona chiefs, and includes many archeological sites. In addition, the park maintains a commitment to preserve traditional uses of the area, including fishing, swimming, and picnicking. In 1978, the park name was changed to Puuhonua o Honaunau N.H.P. The seaward park boundary ends at the high-tide line.

To find enabling legislation documents on-line follow the “Policy & Legislation” link from the Pacific Island Network website ([www1.nature.nps.gov/im/units/pacn](http://www1.nature.nps.gov/im/units/pacn)).

### Geographic Setting

Puuhonua o Honaunau N.H.P. is 182 acres in size and is located seaward of Honaunau village, on the southwest side of the Island of Hawaii (see map below). The population of Hawaii Island is approximately 148,700; and about 5,600 live in the Honaunau region. Currently, land use in the area is primarily agricultural and fairly low density residential. However, development pressure is likely to expand to this area with the growth of the Kona urban area. The Island of Hawaii is the largest and youngest of the Hawaiian Islands, with several potentially active volcanoes, including Kilauea, Mauna Loa, and Hualalai. Puuhonua o Honaunau National Historical Park (PUHO) is located at the shoreline on Mauna Loa, which most recently erupted in 1950 and 1984. Lava flows



within park boundaries are between 750 and several thousand years old. The west coast or leeward side of the island is drier than the east. The park receives a median of 26 inches of rain per year (Deverse, 2005) The park is primarily coastal in nature. However, a separate upland parcel is owned by the park, and currently provides dormitory and training space, as well as a garden/nature trail devoted to native plants.

## **Significant Natural and Cultural Resources**

Natural resources include several brackish water or anchialine fishponds, anchialine pools and freshwater springs, a cliff providing habitat to rare plants, coastal strand communities and areas which were once dryland forest. While marine waters are outside park boundaries, they include extensive coral reefs and habitat of endangered hawksbill (*Eretmochelys imbricate*) and threatened green (*Chelonia mydas*) sea turtles, the endangered Hawaiian monk seal (*Monachus schauinslandi*) and (seasonally) endangered humpback whales (*Megaptera novaeangliae*). Spinner dolphins (*Stenella longirostris*) are seen off the park and in Honaunau Bay. Critical vegetation resources are coastal strand and marsh surrounding anchialine pools; these support primarily native vegetation. Several rare native plant species live in the park, in addition to Polynesian introductions which are managed as part of the historic landscape. PUHO supports only one known individual of the species of concern pua pilo (*Capparis sandwichiana*). The endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) is found in the park.

The park is focused on the Place of Refuge, an area providing sanctuary to those who had broken the ancient laws. There is a Great Wall delineating the site, plus a thatched temple site, several heiau or rock temple platforms, ancient slide routes, village remains, and fishponds. These sites remain sacred to present day Hawaiians. The construction of these sites was with the Hawaiian dry laid stonework, vulnerable to vibration and visitor impacts.

## **Resource Management Priorities**

A 1991 park management document, titled Statement for Management, says that the NPS objective is "to restore and maintain the historic scene of the Puuhonua, Palace Grounds, and house complexes in the park to the year 1819." This includes removing alien vegetation and restoring native and Polynesian plants present in the early 1800's.

The Park has discussed designating wetland and strand communities as special ecological areas. Several endangered plants are maintained in cultivation. Management concerns include non-native invasive plants, feral predatory mammals, introduced predatory fish in ponds, and upland development and associated impacts on water quality.

## **NATURAL RESOURCES**

### **Focal Ecosystems and Processes & Species**

- Coastal strand community and resources
- Anchialine pools
- Rare plants in cliff refugia
- Bird communities

Coastal resources include a beach strand community, rocky shores, sand beaches, tidepools, and the offshore reef. Although the reef is not within park jurisdiction, it is a

major resource which attracts many visitors to the park area and is affected by terrestrial conditions within and above the park. Adjacent to the rocky shoreline, beach strand communities also contain several native species, as well as Polynesian introductions.

Anchialine pools contain several rare shrimp species and provide habitat for a native damselfly (*Megalagrion xanthomelas*.) that is a candidate for endangered status through the U.S. Fish and Wildlife Service. Several anchialine (brackish water) pools in the park were historically used as waterholes, including several submerged springs located close to the shoreline. A small brackish wetland surrounds the culturally modified anchialine pools known as the Royal Fishponds.

The Keanae pali (cliffs) is a refugium for several native plant species rare in the park (Hawaiian leadwort (iliee, *Plumbaga zeylanica*), and alaala wai nui, (*Peperomia* sp). Remnants of native dryland forest also exist in isolated patches near the cliff. Shore birds that frequent the Honaunau region are the Pacific golden plover (kolea, *Pluvialis dominica*), ruddy turnstone (akekeke, *Arenaria interpres*) and in less abundance wandering tattler (ulili, *Heteroscelus incanus*). The Hawaiian owl, (pueo, *Asio flammeus sandwichensis*) and the Hawaiian duck (koloa maoli, *Anasi wyvilliana*) are sometimes seen.

***Threatened and Endangered Species:*** The endangered Hawaiian hoary bat is seen in the park. No threatened or endangered plant species have been identified as still naturally occurring within the park, but several endangered species are cultivated in the disjunct upland garden parcel, including a loulou endemic to South Kona (*Pritchardia shautaueri*). The endangered coastal loulou palm (*Pritchardia affinis*) has been planted near headquarters. At the Park Service T&E listing the following are also listed for PUHO: Hawaiian hawk (E), loulou (E), monk seal (E), green sea turtle (T) The green turtle does beach within the park, and the other mammals are found offshore in marine waters.

### **Threats & Stressors**

- Surrounding land use and development pressures
- Erosion from improper human development
- Groundwater and other pollution
- Sea level rise, storms, and potential tsunami
- Invasive species (plants and animals)
- Park operations (herbicide use, trail fill, etc)
- Marine recreational pressure
- Harvesting activities
- Archeological thievery/vandalism

Development of land upslope from PUHO will increase the opportunities for establishment of new invasive species within park boundaries. Increased land use negatively impacts the quality and quantity of groundwater influx into anchialine pools, fishponds, and springs. The current land use in this area is primarily agricultural, although new housing developments are likely to become more common. Septic leach

fields are likely to be installed as the surrounding lands are urbanized. These systems increase the potential for microbial contamination and organic enrichment of water resources downslope. The combination of sea level rise and land subsidence combined with storm events provides a substantial threat to natural resources in this coastal park. Kilauea Volcano, located to the east, often creates vog (volcanic smog) conditions that degrade air quality and aesthetic viewsapes.

The Royal Fishponds and other anchialine ponds are subjected to a high degree of sedimentation, which disrupts colonization by native invertebrates and encourages the proliferation of invasive predators such as Tilapia (*Oreochromis* sp.) fish. This combination of sedimentation and introduction of alien species alters the balance of the natural pond ecosystem, leading to change in pond conditions and loss of biodiversity.

Large numbers of park visitors and related maintenance activities are significant stressors on park resources. Beach and trail erosion, mainly caused by high surf, is accelerated by foot traffic. The current management practice is to place crushed coral fill, purchased from commercial sources, and of unknown quality, to repair the trail. This fill likely contributes to turbidity and sedimentation of nearshore and coastal resources.

Introduced animals, including predatory mammals and fish, are direct threats to native species. Several established alien plant species are also a major concern. More than half of PUHO remains covered by alien shrubland, which is dominated by koa haole mixed with other shrubs and grasses, particularly Guinea grass (*Panicum maximum*) The use of agricultural chemicals for weed control has decreased in recent years in the park, but in the past large quantities of now banned chemicals were used for this purpose in the weed control sectors. In the interest of maintaining a historical landscape and protecting the Hawaiian dry masonry, weed control is focused around culturally significant structures, along the shoreline trail and around the royal fishponds near the ocean. The effects of this practice are undetermined.

The coral reef offshore undoubtedly is affected by activities along the shoreline as well as by upslope land use. Withdrawal and contamination of groundwater both affect connected water bodies which eventually flow into the marine environment. Coastal and marine ecosystems may also be affected by runoff and drainage from construction as well as paved areas. Marine recreation both within and adjacent to the park has greatly increased in recent years with unknown impacts. Harvesting of natural resources for food and other uses (including fish, marine invertebrates, and plants) is common at PUHO. To date there has been no monitoring of the recreational use and harvest, therefore the impacts are unknown.

Park staff is continually finding, and documenting with photographs, evidence that historical sites are being routinely searched for artifacts. Large carved stones have disappeared, and heiau walls have been torn apart. The park does not have adequate law enforcement funds to provide comprehensive policing of the back country where these artifacts are found.

## Water Quality Designations

Managers have identified the anchialine pools and nearshore marine waters of PUHO as unique or pristine resources worthy of special attention. Inland surface waters of PUHO are designated “Class 2”; protecting their use for recreational purposes, agricultural and industrial water supplies, and the support and propagation of aquatic life. Marine waters and marine bottom ecosystems occurring in the nearshore areas adjacent to PUHO are classed as “AA” and “T”, respectively; prohibiting pollution by humans and requiring maintenance of their natural wilderness character. As of 2004, there are no water bodies within PUHO that are listed as impaired by the State of Hawaii although, four miles to the north, Kealakekua Bay has been listed as impaired by high turbidity. Increasing upslope development, the use of cesspools by local homeowners, and increasing use of Honaunau Bay for recreation pose threats to water quality.

## CULTURAL ISSUES

- Cave protection
- Restoration of historic vegetation and wildlife
- Maintenance of historic structures
- Improve fishponds and anchialine pool conditions
- Maintain traditional harvesting opportunities

PUHO contains quite a few caves, which have been discussed in historical writings. Many of the caves have been used as burial sites. Out of respect for traditional Hawaiian beliefs, these caves have not been inventoried for cultural or natural resources. Caves without burials should be inventoried for natural and cultural resources. Security remains an issue and the park has worked to secure cave entrances to prevent unauthorized entry.

In ancient times the area above the park was largely barren lava with pili (*Heteropogon contortus*) common in soil pockets. Pili grass was used for house thatching. Near shoreline shady groves of coconut (*Cocos nucifera*) were cultivated along with hala (*Pandanus tectorius*), kou (*Cordia subcordata*), and ti (ki, *Cordyline terminalis*). Noni (*Morinda citrifolia*), a medicinal plant, is common. Monitoring is needed to assess the health of these communities and restoration opportunities.

The Hawaiian drylaid walls and thatched temple deteriorate over time and periodic maintenance and reconstruction is required.

The fishponds have become eutrophic and plans are underway to dredge the sediments, but cultural analyses must be performed first.

Traditional fisheries still occur for opihi (*Cellana* sp), pipipi (*Nerita* sp) and aama (a crab, *Grapsus grapsus*) are also collected along the shoreline and in tidepools. Wana (*Centrechinus paucispinus*) are collected seasonally for their edible gonads. Population estimates are not available for these species, nor are there estimates of the impact of fishing pressure. This knowledge is necessary to maintain these traditional harvests.

## MANAGEMENT ISSUES

### **Park Management (General Management Plan, Resource Management Plan):**

The goal of the resource management plan is to preserve the parks historical scene as it was pre-European contact, until the early 1900's, and to interpret the adaptations of the historical Hawaiians to their environment.

Park management documents (General Management Plan, Resource Management Plan, etc.) are available on-line at the NPS intranet site ([www1.nrintra.nps.gov/im/units/pacn/parks/mgmt\\_docs.htm](http://www1.nrintra.nps.gov/im/units/pacn/parks/mgmt_docs.htm)). This website is available only from NPS computer networks. Inquiries about public access should be directed to the park.

Continued residential development and agricultural landuse on upslope lands is also a concern. The community of Honaunau uses cesspools and septic tanks for waste, and there is high potential for fertilizer and pesticide runoff.

A challenge to resource managers at PUHO is attempting to limit destruction of cultural and natural resources while allowing large numbers of visitors. The park is charged with maintaining recreational activities that historically occurred in the area. Fishing, tidepool swimming, swimming at the adjacent snorkeling harbor, hiking, picnicking, and collecting food organisms are common activities. Erosion from foot traffic within the complex is a continuous problem. Trails are currently maintained with the addition of fill material. Fill is also used to stabilize aging coconut palms in order to maintain the temple grove as directed in the park's management documents. The coconut groves, trail, and archeological resources near the shore are progressively eroded during storm events. A better understanding of the use of fill materials in this area is needed. In addition, increasing impacts are likely from high surf as sea level rise and land subsidence occurs.

Natural resource management at this park includes weed control and restoration of the historic landscape using native Hawaiian and Polynesian plants. Many exotic plant species in culturally significant areas are targeted for removal, often requiring the use of chemicals. Alien predatory species within the park include both feral mammals and non-native fish (Tilapia & topminnows). The presence of mongoose and feral cats threaten native birds. Likewise alien fish prevent successful recolonization of anchialine pools by native shrimp and insects.

Park headquarters are located in buildings intended to be temporary structures, which were erected in the 1960's over coastal archeological sites. Maintenance facilities and portable chemical toilets are also located in this area. Park development plans include relocating these structures away from culturally and naturally sensitive sites. Management will also address runoff and drainage from paved areas (the upper parking lot and roads) within the park. Limitations in funding and delays in replacing key staff have also hampered work in this park.

## INVENTORIES

### Existing and Ongoing Inventories in Park

**Vegetation:** Yen conducted an ethnobotanical survey in 1971, including suggestions for restoration to historical conditions (Yen 1971). Two vascular plant surveys have been completed. The first complete vascular plant checklist was published in 1986 as the result of surveys made in the Park during wet and dry periods over three successive years (Smith et al. 1986). A vegetation map was published with the 1986 checklist (Leishmann 1986). New surveys were done in 1992-93 (Pratt and Abbot 1996). The vegetation map was updated in 2003 by Park staff.

Vegetation surveys carried out in the park have recorded a total of 134 vascular plant species. Nearly three-quarters of these (96 species), were alien to Hawaii. Twenty-three species (17%) are indigenous (native to Hawaii, but occurring naturally outside of Hawaii), six species (4%) are endemic (occurring naturally in Hawaii and found nowhere else), and fifteen species (11%) are Polynesian introductions (brought to Hawaii many centuries ago by the first Polynesian settlers).

Native trees found along the shoreline include milo (*Thespesia populnea*), hala (*Pandanus tectorius*), and naupaka kahakai (*Scaevola sericea*). Native sedges found near the ponds and the Great Wall consist of makaloa (*Cyperus laevigatus*) and mauu akiaki (*Fimbristylis cymosa*).

Most of the twenty-three native species found during the last botanical survey were concentrated in the developed part of the Park near the Visitor Center or were growing near the brackish pools or along the coast. Nine native species were noted in the alien shrub-dominated upland portion of the Park, but these native plants were scattered in very low numbers.

Among these native species of the shrubland were the former candidate endangered species pua pilo or maiapilo (*Capparis sandwichiana*), the uncommon Hawaiian moon flower vine (*Ipomoea tuboides*), and pili grass (*Heteropogon contortus*). The only native plants that may be considered common in the Park are the low-growing shrub uhaloa (*Waltheria indica*), makaloa sedge (*Cyperus laevigatus*) of the ponds, and the coastal naupaka kahakai and *Fimbristylis cymosa*.

Voucher specimens exist for about 2/3 of the species. In 1998 alien plants that were rare and uncommon, thus easily removed, were described, and a status report given of those eliminated since the last survey. In 1992-94, weed frequency and estimated cover-abundance data were collected in a belt along transects (Pratt and Abbott 1996b). This baseline data will be significant in monitoring programs to determine trends in alien plant cover.

A contract to analyze pollen deposits in the sediments of a fishpond was signed in 2004, to gain an understanding of historic vegetation patterns. The final report is due July 2005.

Invasive plants such as buffel grass (*Cenchrus ciliaris*), prickly pear cactus (*Opuntia ficus indica*) and date palm (*Phoenix* sp.) are a high priority for removal.

**Terrestrial Vertebrates:** The endangered Hawaiian hoary bat is known to frequent the park. A bat survey was done in April, 1993 by Aeder and Jacobs. An inventory is currently underway for bats through the Inventory and Monitoring program, and bats are frequently sighted.

Bird species have been inventoried through one systematic survey (Morin 1996) and observations by park staff and others. Morin (1996) documented 12 bird species from fall-winter and spring-winter surveys using 29 bird count stations located throughout the park. Species observations by park staff increase the total count to 26 species. Most species present are introduced escaped cage birds. The upland park parcel was not censused but the endangered Hawaiian Hawk, (io, *Buteo solitarius*), has occasionally been seen soaring above the parcel by park staff. Because of its heavily altered vegetation and other lowland characteristics (e.g. infestation with mosquitoes and other avian disease vectors, high numbers of mammalian predators, etc), Puuhonua o Honaunau currently does not maintain endemic bird species (Morin 1996). The Park is a likely site for detecting the spread of introduced bird species, or even the occurrence of newly introduced species, due to its high visitation and relative proximity to urban development.

Introduced mammals such as rats, mice, feral goat, mongoose, cats, pigs, and cattle have been observed in the park.

Reptiles commonly found in the park include three species of geckos and three species of skinks, according to the PUHO site conception plan. In a recent survey (Bazzano 2005), gold dust day gecko, (*Phelsuma laticauda*) was found to be rapidly increasing in numbers. The green anole (*Anolis carolinensis*) was found at the upper garden plot, which tends to be wetter. The stump-toed gecko (*Gehyra mutilate*) and mourning gecko (*Lepidodactylus lugubris*) are less aggressive, and were found in smaller numbers. The house gecko (*Hemidactylus frenatus*) was common at PUHO. A tree gecko (*Hemiphyllodactylus typus*) was observed and the metallic skink (*Lampropholis delicate*) was found at the upland gardens only.

**Invertebrates:** Terrestrial and riparian invertebrate faunas were surveyed in 1992 (unpublished project). About 100 species have been collected within the park out of a total of 609 insect species recorded for the Kona district. A total of 130 species, including 15 natives, has been recorded from the park.

**Freshwater and Anchialine Pool Communities:** Maciolek and Brock (1972) surveyed 318 anchialine pools along the Kona Coast and inventoried environmental and biological

characteristics. In 1987 the Natural Heritage Program of the Nature Conservancy of Hawaii published a biological database of rare species and natural communities in anchialine pools in Hawaii.

In 1992, Oceanic Institutes Summer Aquaculture Workshop students and staff evaluated a fishpond inside PUHO located along the south side of the walking trail. At this site, four locations were monitored for temperature, pH, salinity, and dissolved oxygen. In 1999 Chai took temperature, salinity, pH, tidal fluctuation, and made a list of species present in an anchialine pool in PUHO. The study found that the overall ecological health of the pools is poor. The ponds are not viable habitat for fish traditionally stocked for ali'i because of degraded water quality and competitive tilapia. The ponds also are important from a biogeographical perspective since no other anchialine pools are located between Kailua-Kona and Milolii.

A multi-park inventory of anchialine pools is currently underway, through a cooperative agreement between the USGS and NPS. The inventory includes a survey of the insect species associated with the pools.

***Water Quality:*** In 1999 the Water Resources Division of NPS conducted a baseline water quality inventory of the Park. Waters in the Bay are deemed safe for swimmers.

***Air Quality:*** For a six-month period particulate matter was measured at the park as part of VOGNET, a volcano emission monitoring network. VOGNET is a collaborative project between the NOAA CMDL observatory at Mauna Loa and Hawaii Island high schools. Particulate levels are acceptable within the park at sea level. No other studies have been conducted to estimate atmospheric nutrient input.

***Weather:*** Only rainfall is recorded. In the past both temperature and rainfall were measured. Data sheets are filed in the park.

### **Priorities for New Inventories in Park**

***Vegetation:*** Status and trend data is needed on the health of native vegetation and the spread of invasives.

***Marine Communities:*** Analysis of recreational use and impacts is needed. The tidepool invertebrate communities should be described, and the potential for visitor impacts on the health of the pools. It is also important to ascertain if visitors could be in danger from toxic reactions if they were to handle tidepool organisms.

***Water Quality:*** More data is needed on water quality baseline parameters and trends. The impact of the crushed coral fill should be evaluated to see if use of the fill is elevating sediment levels and affecting water quality. Photos have documented sediment plumes washing out from the cove.

### **Buffer Zone Inventories**

**Marine Communities:** The Park has some minimal information on the species of recreationally harvested fish near Park waters (Joyce 1996). In 1979 a study was conducted on the impact of small boat anchoring on the near-shore reef environment. It was determined that two major and one smaller area were showing evidence of anchoring. The author recommended that anchoring be eliminated or controlled in the reef areas (Kinzie 1979).

Echinoid fauna in Kealakekua and Honaunau Bays were surveyed in 1971 (Ebert 1971). The Resource Management Plan provides the following information about the benthic communities: Visible algae is almost entirely intertidal and benthic seaweed populations are sparse. A single red alga, (*Tolpocladia glomerata*), is generally observed at depths greater than two meters. The coral *Pocillopora meandrina* is found to a depth of five meters, castle coral (*Porites pukoensis*) extends to a depth of 15 meters, and finger coral extends to a depth of 20 m. Gastropods (cowries, cones, bivalves, clams and oysters) are present. *Echinometra mathaei* is the most abundant urchin in Honaunau Bay and the uncommon slate pencil urchin, *Heterocentrotus*, contributes greatly to biomass. The only larger crustacean seen in numbers is the cleaning shrimp, *Stenopus hispidus*. The most common fishes are yellow tang (*Zebrasoma flavescens*) and kole (*Ctenochaetus strigosus*).

In 1968 Rhodes compiled field notes on observations of marine life near PUHO. Surveys of the fish fauna were conducted by Doty (1969 in Ludwig et al.1980). Doty found 98 species and documented evidence of overfishing and commercial collection of corals. In comparison, Ludwig et al. (1980) found greater fish abundance and species diversity (163 fish species) indicating potential recovery from earlier perhaps more intense human disturbance.

An inventory of marine communities is currently underway through the Inventory and Monitoring Program.

Tagging programs are conducted for green sea turtles by the U.S. National Marine Fisheries Service along the West Hawaii coast, including PUHO.

## MONITORING

### **Existing Monitoring in Park**

**Water Quality:** Kiilae Stream was monitored for physical and chemical water quality parameters by the USGS from 1974 to 1982 when the stream was relatively perennial. The stream flow gauge is now inactive, and the stream is considered intermittent, due to upstream development and water diversions. The USEPA updated the 2002 Hawaii coastal EMAP sample design to include open coastal areas as well as embayments in the 2004 assessment. Preliminary site selection maps indicate two reserve sampling locations near PUHO. One site is located in Kealakekua Bay, to the north, and the other near Hookena, to the south of PUHO. Sample collection has been delayed until early in 2005. Dr. David Foote of the USGS Pacific Islands Ecosystem Research Center has a

funded I&M project to inventory selected invertebrates and water chemistry in some anchialine pools.

### **Priorities for New Monitoring in Park**

***Vertebrates:*** Monitoring of threatened and endangered species, sensitive, native and exotic animals were identified by park staff as important monitoring needs.

***Water Quality:*** Groundwater quality and quantity should be monitored, especially if development on surrounding lands becomes intense.

### **Existing Buffer Zone Monitoring**

***Vegetation:*** In 2002, the USGS surveyed the presence, frequency, and distribution of weeds on major roadsides including those around PUHO. This project will be ongoing while support is available.

***Marine Communities:*** Monitoring of marine areas near this park includes green sea turtle research and tagging by the National Marine Fisheries Service.

West Hawaii Aquarium Project (WHAP) has been studying the distribution and abundance of aquarium fishes along the West Hawaii coast since 1998 and the value of marine reserves. They found that aquarium fish populations were declining prior to establishment of the reserves. They concluded better knowledge is needed of larval recruitment processes.

NPS Pacific Island Coral Reef Program (PICRP) initiated work in 2003 with USGS and contractors for aerial photography, to produce high resolution coral reef habitat classification maps for the Kona parks and coast. A comprehensive marine GIS data base will be constructed to improve knowledge for monitoring and management of the Kona reef ecosystem structure and to track trends in ecological and oceanographic processes to detect ecological changes in coral reefs in space and time.

***Water Quality:*** The Hawaii State Department of Health monitored offshore waters of Honaunau Bay from 1983 to 1994 for physical and chemical parameters relating to land use. They also monitored nearby recreational swimming areas at Hookena Beach, Kealakekua Bay, and Honaunau Bay for bacterial indicators of sewage pollution and limited water quality parameters from 1973 to 1997. The Department posted a warning sign in spring 2004 that Honaunau Bay had high levels of fecal coliform. Trends in recreational use of Honaunau Bay should be monitored.

## **CONCLUSIONS**

PUHO contains many cultural features sacred to the Hawaiian people, and important for historical understanding. The natural resources are the scenic beauty, non-urbanized habitat, and coastal nature of the park. The natural setting is becoming rare on the West

Hawaii coast as shoreline development increases. The park provides valuable habitat for the endangered Hawaiian hoary bat, and native plants. The offshore coral reefs remain in fairly good condition and sustain a fairly high level of recreational use, as well as fishing pressure. However, the integrity of these resources is threatened by forces outside of the parks control. Changes in sea level, upslope and offshore development, recreational overuse, and pollution could be very destructive forces for the park. Exotic species have already damaged the natural resources. Fish ponds have become eutrophic.

The PUHO Park Superintendent is based at KAHO and has joint responsibilities for the two parks, as does other staff. The park needs additional law enforcement funding in order to preserve its archeological sites from looters. Park facilities are inadequate, and need to be reconstructed. Park exhibits need to be refurbished. The needs for cultural inventory can sometimes delay the implementation of natural resource protection methods. When adequately staffed, future management efforts will focus on restoration of the anchialine pools (with special focus on the fishponds), protection and outplantings of native vegetation, feral mammal management, obtaining more natural resource data, and preservation of cultural sites.

## REFERENCES

- Aeder, Mark, and David Jacobs. 1993. Pu`uhonua o Honaunau National Park bat survey.
- Bazzano, Jason. 2005. West Hawaii Herpetological Survey, unpublished report, Inventory and Monitoring Program files, National Park Service, Hawaii Volcanoes National Park.
- Chai, Mitchell. 1999. Restoration on the Pu`uhonua o Honaunau anchialine fish ponds.
- Davis, Dan A., and George Yamanaga. 1968. Preliminary report on the water resources of the Kona area, Hawaii; Circular - Hawaii Division of Water and Land Development.
- DeVerse, Kimber 2005. Supporting documents for NPS PACN Monitoring Plan. Water quality report.<http://www1.nature.nps.gov/im/units/pacn/monitoring/plan/2003-pre/waterq/index.htm>
- Doty, Maxwell S. 1968. The ecology of Honaunau Bay, Hawaii: final report; Botanical science paper.
- Ebert, Thomas A. 1971. A preliminary quantitative survey of the echinoid fauna of Kealakekua and Honaunau Bays, Hawaii. *Pacific Science*: **25**:1, p. 113-131.
- Kimura, Larry Lindsey. 1969. Algae: Honaunau, South Kona, Hawaii.
- Kinzie, Robert A. 1979. The impact of small boating activities on the reefs in Honaunau Bay. Review copy, draft.
- Leishmann, Jack. 1986. Vegetation map of Puuhonua o Honaunau National Historical Park, Hawaii.
- Ludwig G. M., L. R. Taylor, Jr., and D. M. Imose. 1980. Summer census of the reef-fish community of waters adjacent to Puuhonua o Hononau National Historical Park, summers 1974-78.
- Maciolek, and Brock.. 1972. Aquatic survey of the Kona Coast Ponds, Hawaii Island. UNIHI-Seagrant-AR-74-04: University of Hawaii.
- Morin, Marie. 1996. Birds of Puuhonua o Honaunau National Historical Park. Technical report 106: Cooperative National Park Resources Studies Unit, University of Hawaii at Manoa.
- Nature Conservancy. 1987. Biological database of rare species and natural communities in anchialine ponds in the state of Hawaii. Natural Heritage Program, Nature Conservancy of Hawaii.
- National Park Service, Water Resources Division. 1999. Baseline water quality data: inventory and analysis: Puuhonua o Honaunau National Historical Park.
- National Park Service, Puuhonua o Honaunau National Historical Park. 2000. PUHO site conception plan.
- Neighbor Island Consultants. 1972. An assessment of environmental impact resulting from the development of a boat launching ramp and deepening of the existing navigational channel, Honaunau Bay, Hawaii.
- NOAA. 1977. Kealakekua Bay to Honaunau Bay.

- Oceanic Institute. Summer Aquaculture Workshop Students and Staff. 1992. Evaluation of anchialine fishponds Hele I Palala at Puuhonua o Honaunau National Historical Park, Honaunau, Hawaii.
- Pratt, Linda and Abbot. 1996. Vascular plants of Puuhonua o Honaunau National Historical Park; Cooperative National Park Resources Studies Unit Technical Report Series #105.
- Rhodes, Raymond J. 1969. A summary of the Kona Coast general oceanography for the City of Refuge National Historical Park, Honaunau, Hawaii and Report on marine biology study at City of Refuge.
- Smith, Clifford W., L. Stemmermann, Paul K. Higashino, and E. Funk. 1986. Vascular plants of Puuhonua o Honaunau National Historical Park, Hawaii; Cooperative National Park Resources Studies Unit Technical Report Series #56.
- USGS, Water Quality Monitoring.
- West Hawaii Aquarium Project. Descriptions provided online at <http://coralreefnetwork.com/kona/>
- Yen, Douglas. 1971. An ethnobotanical survey of the national parks at Honaunau and Kalapana on the Island of Hawaii and Kipahulu, Maui.